PTO 05-1245

CY=JA DATE=19850917 KIND=A
PN=60-182119

# CORE MANUFACTURING METHOD
[Makitetsushin no seizouhouhou]

Tadao Murata

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. December 2004

Translated by: FLS, Inc.

| | | |
|---|---|---|
| PUBLICATION COUNTRY | (19): | JP |
| DOCUMENT NUMBER | (11): | 600182119 |
| DOCUMENT KIND | (12): | A [PUBLISHED UNEXAMINED APPLICATION] |
| PUBLICATION DATE | (43): | 19850917 |
| APPLICATION NUMBER | (21): | 59036707 |
| APPLICATION DATE | (22): | 19840228 |
| INTERNATIONAL CLASSIFICATION | (51): | H 01 F 41/02 |
| INVENTOR | (72): | MURATA, TADAO |
| APPLICAN | (71): | TOSHIBA CORPORATION |
| TITLE | (54): | CORE MANUFACTURING METHOD |
| FOREIGN TITLE | (54A): | MAKITETSUSHIN NO SEIZOUHOUHOU |

SPECIFICATION

1. Title of the Invention

CORE MANUFACTURING METHOD

2. Claim

A core manufacturing method characterized by: using a multi-level core former in which multiple winding parts having different inner diameters are aligned sequentially from the small diameter side on the same axis line; winding an amorphous magnetic alloy ribbon around each of the winding parts of this core former; subjecting the amorphous magnetic alloy ribbon to a strain-removing heat treatment in this wound condition; and concentrically assembling the layers of the amorphous magnetic alloy ribbon wound around the winding parts of said core former.

3. Detailed Explanation of the Invention

[Technical Field of the Invention]

The present invention pertains to manufacturing methods for cores consisting of amorphous magnetic alloy ribbons.

[Technical Background of the Invention and Problems Thereof]

Recently, manufacturing of cores utilized for transformers, etc. by using amorphous magnetic alloy materials having excellent magnetic properties has been investigated. These amorphous magnetic alloy materials are ribbons containing alloys made up of metals such as iron, cobalt, etc., and of elements, such as boron, carbon, etc. as the components, and they are produced by means of a rapid quenching technique. Compared to silica steel plates, which are conventional core materials, they have much less core loss and exciting current and exhibit superb excitation

characteristics.

However, since an amorphous magnetic alloy material (hereafter referred to as amorphous magnetic alloy ribbon) is produced by a rapid quenching technique, thermal stress remains inside the material. Therefore, the excellent magnetic properties that the material originally has cannot be obtained unless the strain is removed by performing a heat treatment (annealing) inside a magnetic field. For this reason, when cores are manufactured by using amorphous magnetic alloy ribbons, the amorphous magnetic alloy ribbons are subjected to strain-removing annealing after being wound.

In this case, since the appropriate ranges of heat treatment conditions for an amorphous magnetic alloy ribbon are narrow, it is necessary to set the temperature and retention time within prescribed ranges in order to obtain excellent magnetic properties. In other words, a heat treatment temperature that is too low or too high causes the recovery rate (the rate at which the internal strain is removed) of the magnetic properties of the amorphous magnetic alloy ribbon to be small. An allowable temperature range of ±5°C is preferred, and the magnetic properties deteriorate when it is ±10°C or more. When the retention time of the heat treatment temperature is long, the magnetic properties of the amorphous magnetic alloy ribbon [1] deteriorate. For this reason, it is necessary to allow the temperature of the entire ribbon to be even (±5°C) in a short period of time in order to subject the amorphous magnetic alloy ribbon to a strain-removing heat treatment without causing the material to lose its original superb magnetic properties.

Therefore, in the manufacture of cores in which a conventional amorphous magnetic alloy ribbon is utilized, an amorphous magnetic alloy ribbon [1] is continually wound around a core former [2] while aligned uniformly in the width direction to obtain a wound body [3], and this wound body [3] is subjected to a strain-removing heat treatment.

However, when the wound body [3] that has the above winding structure is heat-treated, the temperatures of different parts of the wound body [3] become different in the direction of the winding thickness and in the direction of the width, and this make it difficult to increase or decrease (cool down) the temperature of the entire wound body [3], in other words, the entire amorphous magnetic alloy ribbon [1] that has been wound, to an even temperature in a short amount of time. As a result, the superb magnetic properties of the amorphous magnetic alloy ribbon [1] deteriorate. Figure 3 is a graph indicating one example of the temperature distribution in the wound body [3] observed in the core thickness direction during a temperature increase (410°C, retained for 1 hour) in a heat treatment. According to this graph, the temperature of the center of the wound body [3] in the thickness direction is particularly low compared to the temperatures of the inner periphery part and outer periphery part, and a temperature difference of 5 ~ 25°C is generated between them. Figure 4 is a graph indicating one example of the temperature distribution in the wound body [3] observed in the width direction during the same temperature increase as that earlier. According to this graph, the temperature of the center of the wound body [3] in the width direction is particularly low compared to the temperatures of

both ends, and a temperature difference of 2 ~ 5°C is generated between them. In this manner, when the wound body [3] is heat-treated, there will be temperature differences in parts of the wound body [3], the temperature distribution becomes uneven, and a temperature that is even throughout the wound body [3] cannot be achieved. If the temperature is maintained until the center part of the bound body [3] reaches the prescribed heat treatment temperature, the temperature of the amorphous magnetic alloy ribbon [1] becomes high at the outer periphery (winding end) and the inner periphery (winding start) of the wound body [3] and crystallization begins. This causes the magnetic properties to deteriorate.

[Purpose of the Invention]

The present invention was completed based on the above situation, and its purpose is to supply a core manufacturing method in which cores consisting of amorphous magnetic alloy ribbons that have excellent magnetic properties can be manufactured without lowering the magnetic properties.

[Outline of the Invention]

In the core manufacturing method of the present invention, cores are formed by means of the following: using a multi-level core former in which multiple winding parts having different inner diameters are aligned sequentially from the small diameter side on the same axis line; winding an amorphous magnetic alloy ribbon around each of the winding parts of this core former; subjecting the amorphous magnetic alloy ribbon to a strain-removing heat treatment; and concentrically assembling the layers of the amorphous magnetic alloy ribbon wound around the winding

parts of the core former. In other words, by subjecting the amorphous magnetic alloy ribbon to a strain-removing heat treatment while it is wound around the core former in multiple divided layers, the temperature of the entire wound amorphous magnetic alloy ribbon can be increased or decreased to a prescribed even temperature in a short period of time during the heat treatment. Therefore, the magnetic properties of the amorphous magnetic alloy ribbon can be prevented from deteriorating.

[Working Example of the Invention]

In the following, the present invention will be explained based on a working example indicated in the drawings.

One working example of the manufacturing method of the present invention will be explained based on Figs. 5 through 9.

First, by using a core former [2], shown in Fig. 7, an amorphous magnetic alloy ribbon [1] is wound. The core former [2] has multiple winding parts around which the amorphous magnetic alloy ribbon [1] is wound. These are, for example, 4 rectangular winding parts, [2a], [2b], [2c], and [2d]. The inner diameters, [$d_1$], [$d_2$], [$d_3$], and [$d_4$], of these winding parts, [2a] ~ [2d], around which the amorphous magnetic alloy ribbon [1] is wound are different from one another, and the core former has a multi-level structure in which the winding parts, [2a] ~ [2d], are aligned sequentially on the same axis line from the one with the smallest diameter. In other words, a wound body that is formed by winding the amorphous magnetic alloy ribbon [1] by means of the core former [2] is divided in the thickness direction into multiple layers, and the inner diameters of these layers that consist of the wound amorphous magnetic alloy ribbon [1] are set

as said inner diameters, [$d_1$] ~ [$d_4$], of the winding parts, [2a] ~ [2d]. Therefore, the winding parts, [2a] ~ [2d], wind the amorphous magnetic alloy ribbon [1] in accordance with said divided layers. Moreover, the total of the winding thickness of the amorphous magnetic alloy ribbon wound around each of the winding parts, [2a] ~ [2d], and the thickness of each of the winding parts, [2a] ~ [2d], should be set in a manner such that the heat capacities of the winding parts, [2a] ~ [2d], are as similar to one another as possible. Moreover, the width dimensions of the winding parts, [2a] ~ [2d], are set to be equal to the width of the amorphous magnetic alloy ribbon [1] in this working example.

Then, by rotating the core former [2] by means of a device not shown and by reeling out the amorphous magnetic alloy ribbon [1] from the feeding reel [3] at the same time as shown in Fig. 5, the amorphous magnetic alloy ribbon [1] is wound around the winding parts, [2a] ~ [2d], of the core former [2]. In this case, starting from the one with the smallest diameter, each of the winding parts, [2a] ~ [2d], sequentially winds a prescribed thickness of the amorphous magnetic alloy ribbon [1]. For this reason, the amorphous magnetic alloy ribbon [1] becomes wound by the winding parts, [2a] ~ [2d], in divided layers of prescribed thicknesses, and these layers are provided in steps in the ribbon's width direction. The width-direction intervals of these layers are equal to the width of the amorphous magnetic alloy ribbon [1]. Figure 6 shows a condition in which the amorphous magnetic alloy ribbon [1] is wound around the core former [2].

Next, the amorphous magnetic alloy ribbon [1] wound around the core former [2] in the above manner is subjected to a heat treatment for strain

removal, and the strain that was generated in the amorphous magnetic alloy ribbon [1] is removed. This heat treatment is carried out by heating the amorphous magnetic alloy ribbon [1] to a prescribed temperature inside a treatment furnace filled with an inert gas and by then reducing the temperature by means of cooling. At this time, the amorphous magnetic alloy ribbon [1] becomes heated and cooled in multiple layers while divided by the core former [2] into multiple levels in the direction of the core's thickness. Therefore, the layers of the amorphous magnetic alloy ribbon [1] become heated and cooled by means of the forced convection and heat conduction of the interior of the treatment furnace, and their temperatures become increased or decreased to a prescribed temperature in a short amount of time in uniform conditions. Moreover, heat becomes conducted well in each layer, and the temperature differences of the amorphous magnetic alloy ribbon [1] in the width direction become small. Therefore, the temperature distributions of different parts of the amorphous magnetic alloy ribbon [1] wound around the core former [2] become even, and the temperature of the entire amorphous magnetic alloy ribbon [1] becomes increased or decreased evenly to a prescribed temperature in a short amount of time.

Figure 9 is a graph indicating the thickness-direction temperature distribution (410°C at the time of temperature increase, maintained for 1 hour) of the wound body of the amorphous magnetic alloy ribbon [1] during a heat treatment. As is clear from this graph, the difference between the temperature of the center part (with respect to thickness) of the wound amorphous magnetic alloy ribbon [1] and the temperatures of its

inner periphery and outer periphery is 6°C, which is within the allowable temperature range, ±5°C, in which the magnetic properties will not be lowered as mentioned earlier. By this, the core loss of the amorphous magnetic alloy ribbon [1] can be improved by about 10% compared to the past.

After performing the heat treatment without lowering the magnetic properties of the amorphous magnetic alloy ribbon [1] in this manner, the amorphous magnetic alloy ribbon [1] wound around the winding parts, [2a] ~ [2d], of the core former [2] is assembled in a concentric manner by being shifted in the width direction. Thus, a core [4], shown in Fig. 8, is formed.

Moreover, when winding the amorphous magnetic alloy ribbon [1] around the core former [2] in the above-described working example, it is possible to dispose and wind a silica steel plate, which is for improving the magnetic properties, between the layers of the amorphous magnetic alloy ribbon [1]. In other words, by winding a silica steel plate around each of the winding parts, [2a] ~ [2d], of the core former [2] in advance, by winding the amorphous magnetic alloy ribbon [1] onto each of the silica steel plates, and by then overlapping the amorphous magnetic alloy ribbon [1] of the parts, [2a] ~ [2d], together with the silica steel plates by shifting them in the width direction, the silica steel plates can be easily disposed between the layers of the amorphous magnetic alloy ribbon [1]. This allows the layers of the amorphous magnetic alloy ribbon [1] to be insulated from one another by the silica steel plates, which are equipped with insulation coatings, even if there is no insulation coating on the

surface of the amorphous magnetic alloy ribbon [1]. Therefore, occurrences of eddy currents can be reduced, which is very effective in improving the magnetic properties of the core.

Moreover, in the winding process of the present invention, the amount of shifting of the amorphous magnetic alloy ribbon [1] in the width direction does not need to be the same as the ribbon's width as it was in the above working example. In a case in which the amorphous magnetic alloy ribbon [1] is wound sequentially from the winding part [2a], which is on the smaller diameter side, of the core former [2], the width of the amorphous magnetic alloy ribbon [1] can be altered during winding by using a core former [2] in which the widths of the winding parts, [2a] ~ [2d], are different as shown in Fig. 10. As for the core former [2] shown in Fig. 10, the width of the winding part [2a] is the same as the width of the amorphous magnetic alloy ribbon [1], and the widths of the winding parts, [2b] ~ [2d], are set to be smaller than the width of the ribbon [1]. Therefore, when this core former [2] is utilized, the amorphous magnetic alloy ribbon [1] becomes partially overlapped in the width direction in each of the layers. This makes it easy to shift the layers in the width direction when forming a core after a heat treatment, and therefore, the core can be easily formed.

In addition, application of the present invention is not limited to rectangular cores, and it can also be applied to circular cores.

[Effects of the Invention]

As explained earlier, according to the core manufacturing method of the present invention, cores that can exhibit the excellent magnetic

properties of an amorphous magnetic alloy ribbon can be obtained by performing a heat treatment without spoiling the magnetic properties of the amorphous magnetic alloy.

4. Brief Explanation of the Drawings

Figure 1 is a front view showing a wound body formed by a conventional manufacturing method. Figure 2 is a cross-sectional view of the II-II line in Fig. 1. Figures 3 and 4 are graphs indicating the temperature distributions of a conventional wound body obtained during a heat treatment. Figures 5 through 9 show one working example of a manufacturing method of the present invention. Figure 5 is an explanatory drawing showing a winding process, Figure 6 is a front view showing a condition in which an amorphous magnetic alloy ribbon has been wound around a core former, Figure 7 is a magnified cross-sectional drawing showing the core former, Figure 8 is a perspective drawing showing the core, and Figure 9 is a graph indicating the temperature distribution obtained when the amorphous magnetic alloy ribbon wound around the core former is heat-treated. Figure 10 is a cross-sectional drawing showing a condition of another working example in which an amorphous magnetic alloy ribbon has been wound around a core former.

[1] = amorphous magnetic alloy ribbon; [2] = core former; [2a] ~ [2d] = winding part; [4] = core.

Figure 1

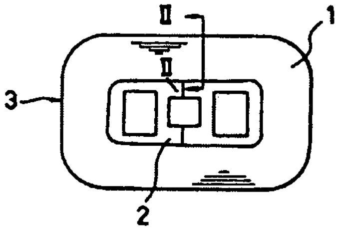



Figure 2

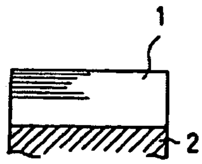
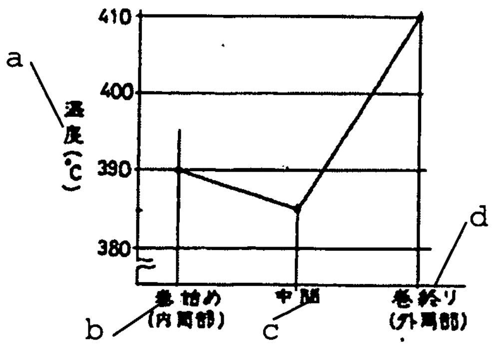
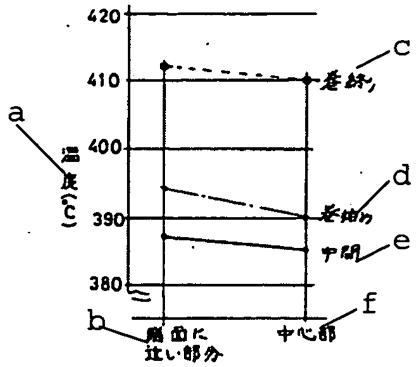



Figure 3




Key: a)temperature (°C); b)winding start (inner periphery part); c)middle; d)winding end (outer periphery part).

Figure 4




Key: a) temperature (°C); b) parts near end faces; c) winding end; d) winding start; e) middle.

Figure 6

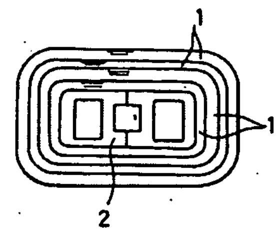



Figure 7

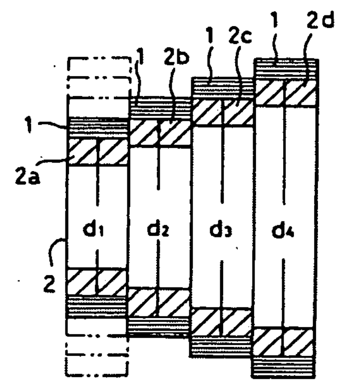



Figure 5

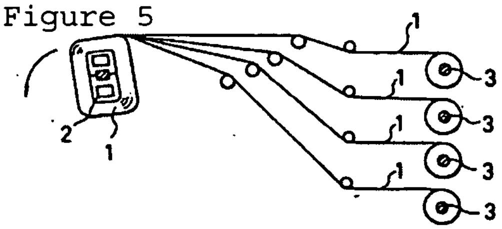



Figure 8

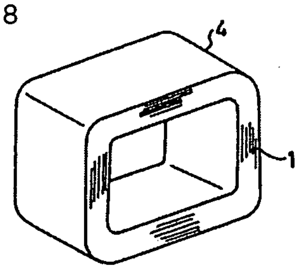
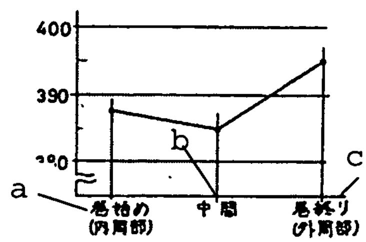



Figure 9




Key: a) winding start (inner periphery part); b) middle; c) winding end (outer periphery part).

Figure 10